

# NPP after launch: Characterizing ATMS performance

The NPOESS Preparatory Project (NPP) mission is scheduled to launch in the fall of 2011. Although several teams from the government and the instrument contractor will be assessing and characterizing the performance of the Advanced Technology Microwave Sounder (ATMS) and the Cross-track Infrared Sounder (CrIS) sounding suite, the NASA NPP Science Team will be paying particular attention to the aspects of these sensors that affect their utility for atmospheric and climate research. In this talk we discuss relevant aspects of ATMS and our post-launch analysis approach.

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**April 28, 2011**

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AIRS Science Team Meeting, Pasadena, 3-5 October, 2000

# *A decade earlier...*

## Microwave Instrument Validation

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## MICROWAVE INSTRUMENT VALIDATION

# Scope of Early Activities

- **Instrument operations**
  - Commanding
  - Health & safety monitoring
- **Instrument assessment**
  - Activation
  - Performance
  - Calibration
  - Pointing
- **Data product assessment**
  - L1a validation
  - L1b validation
  - QA assessment



## MICROWAVE INSTRUMENT VALIDATION

# Instrument Operations

- **All activities focused at EOC/GSFC**
  - Distribution of HK data
  - Receipt of command requests
- **Phase 1 — Activation & verification**
  - First 1-2 months
  - All instrument teams at EOC: Aerojet, INPE, JPL/DPIO
  - Aerojet/INPE prime responsibility; JPL “shadowing”
- **Phase 2 — Validation**
  - Next 1-2 months
  - DPIO assumes operational responsibility
- **Phase 3 — Routine operations**
  - Rest of mission
  - Instruments monitored from JPL IST by DPIO
  - DPIO has full operational responsibility
  - Command requests through AIRS ops advisory board



## MICROWAVE INSTRUMENT VALIDATION Instrument Assessment

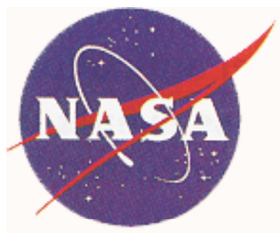
- **Prime responsibility of Aerojet & INPE**
  - JPL will shadow and supplement
- **Activation (by EOC) ~ 1 week**
  - Monitor passive telemetry
  - Get OK from S/C team
- **Performance assessment (by Aerojet/INPE) ~1-2 months**
  - Instrument performance & calibration verification
  - JPL will monitor & check process & conclusions
  - Period ends when performance is “verified” ⇒ Hand-over to JPL/DPIO
- **Pointing verification (by JPL) ~3-9 months**
  - MW instrument pointing
  - MW-IR coalignment



## MICROWAVE INSTRUMENT VALIDATION

# Data Product Assessment

- **Responsibility of JPL**
  - Assistance from Science Team
- **Requires instruments in “science mode”**
  - Occasionally in the early assessment phase
  - Regularly in the late assessment phase
- **L1a first: ~2 months**
  - Verify engineering data (temp’ s, limits, etc.)
  - Preliminary verification: “Use w/caution”  $\Rightarrow$  Proceed with L1b, etc.
- **L1b next: ~3 months**
  - Verify calibration
  - Preliminary verification: “Use w/caution”  $\Rightarrow$  Proceed with L2, etc.
- **QA assessment: ongoing**
  - Verify QA parameters
  - Assess their values
  - Issue regular summary reports



## MICROWAVE INSTRUMENT VALIDATION

# L1a Validation

Start: L+0.5m	End: L+3m	Duration: 2.5m	
	<i>Description</i>	<i>Milestones</i>	<i>Source/Destination</i>
Deliverables	"Use with caution" "Validated" Validation Report	L+30d L+75d L+90d	→Team →Project (world) →Project (world)
Triggers	MW instruments in occasional science mode; L1a processed		
Critical input	MW L1a	Continuous	←TDS
Other input	AMSU-A performance rep't HSB performance rep't Scan symmetry analysis Pointing analysis	L+45d (once) L+45d (once) L+50d (once) L+35d (once)	←Aerojet ←INPE ←MIT ←MCT

- **Approach**
  - Statistical analysis: noise, trends, correlations
  - Comparison with pre-launch & predicted on-orbit values
  - Cross-comparisons between parameters (PRT' s, etc,)



## MICROWAVE INSTRUMENT VALIDATION

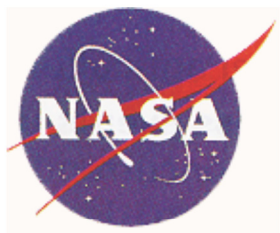
# L1b Validation

Start: L+1m	End: L+12m	Duration: 11m	
	Description	Milestones	Source/Destination
Deliverables	"Use with caution" "Prelim. Validated" Preliminary Validation Report Preliminary Tb Comparison Report "Definitive Validated" Definitive Validation Report Final Tb Comparison Report	L+1.5m L+3m L+4m L+5m L+6m L+7m L+12m	→Team →Project (world) →Project (world) →Team →Project (world) →Project (world) →Project (world)
Triggers	MW instruments in occasional science mode; L1b processed TB comparisons: MW instruments in continuous science mode		
Critical input	MW L1b NOAA L1	Continuous Continuous	←TDS ←NOAA
Other input	ARM/CART MWR (+others?) AMSR-E L1b Residual analysis	L+2m overps. L+2.5m cont. L+3m (once)	←UW ←DAAC ←MIT

- **Approach**

- Statistical analysis: noise, trends, correlations
- Comparison with pre-launch & predicted on-orbit values
- Cross-comparisons between parameters
- Comparisons with other instruments (NOAA-AMSU, AMSR-E, others?)
- Residual analysis with in situ data





## MICROWAVE INSTRUMENT VALIDATION

# QA Verification & Assessment

Start: L+0.5m	End: L+12m	Duration: 12m	
	Description	Milestones	Source/Destination
Deliverables	Preliminary Report L1a	L+2m	→Team
	Preliminary Report L1b	L+3m	→Team
	Final Report L1a	L+5m	→Team
	Final Report L1b	L+7m	→Team
	Monthly assessment reports	L+Xm	→Team
Triggers	Respective products generated		
Critical input	MW L1a	L+15d cont.	←TDS
	MW I1b	L+1m cont.	←TDS
	QA (subset)	L+3m cont.	←TDS
Other input	None		

- **Approach**
  - Verify correctness of QA parameters
  - Assess their values
  - Statistical analysis: variance, trends, correlations
  - Assessment of red/yellow limits



## MICROWAVE INSTRUMENT VALIDATION

# Pointing

Start: L+0.5m	End: L+12m	Duration: 12m	
	Description	Milestones	Source/Destination
Deliverables	"Use with caution" "Use for retrievals" "Validated" Validation Report	L+40d L+60d L+9m L+12m	→Team →Team →Team →Team
Triggers	MW instruments in occasional science mode; L1b processed		
Critical input	MW L1a and/or L1b DEM AIRS pointing analysis results	Continuous L+20d (once) L+50d (once)	←TDS ←TDS ←ACT
Other input	None		

- **Approach — Pointing**
  - Detect edges in swath (counts or Tb' s); Compare with map
  - Determine pointing offsets; Translate to boresight rotations
- **Approach — Co-alignment**
  - Emphasis on along-track alignment (cross-track alignment in S/W)
  - Determine avg. scan line from IR & MW pointing analysis
  - Compare IR & MW scan lines: parallel? offset along-track?
  - Translate scan offset to time offset



## MICROWAVE INSTRUMENT VALIDATION

# Pointing Analysis: Objectives

- **Validate instrument pointing: actuals vs. specs**
- **Verify AIRS-MW coalignment: actuals vs. specs**
- **Determine instrument rotation matrix corrections**
- **Determine AIRS scan sync correction**
- **Determine scanset/golfball groupings**
- **Determine any necessary S/W modifications**



## MICROWAVE INSTRUMENT VALIDATION

# Pointing Analysis

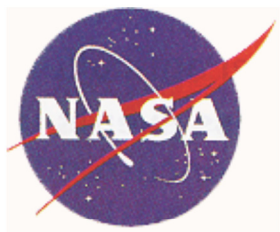
- **Methodology**
  - Compare edges in swath with coastline map
  - Determine offsets
  - Translate map offsets to angular offsets
- **Instrument rotation matrix corrections**
  - Overall yaw, pitch, roll from angular offsets
  - Use to adjust geolocation coord. transformation matrices
  - After correction: maps should line up
- **Pointing validation**
  - Errors = angular offsets corrected for overall yaw, pitch, roll
- **Co-alignment validation**
  - Compare MW & IR yaw errors  $\Rightarrow$  Helix angle errors
  - Determine along-track MW-IR offsets  $\Rightarrow$  Scan sync errors
- **AIRS scan sync correction**
  - Optimal along-track offset, translated to sync time offset



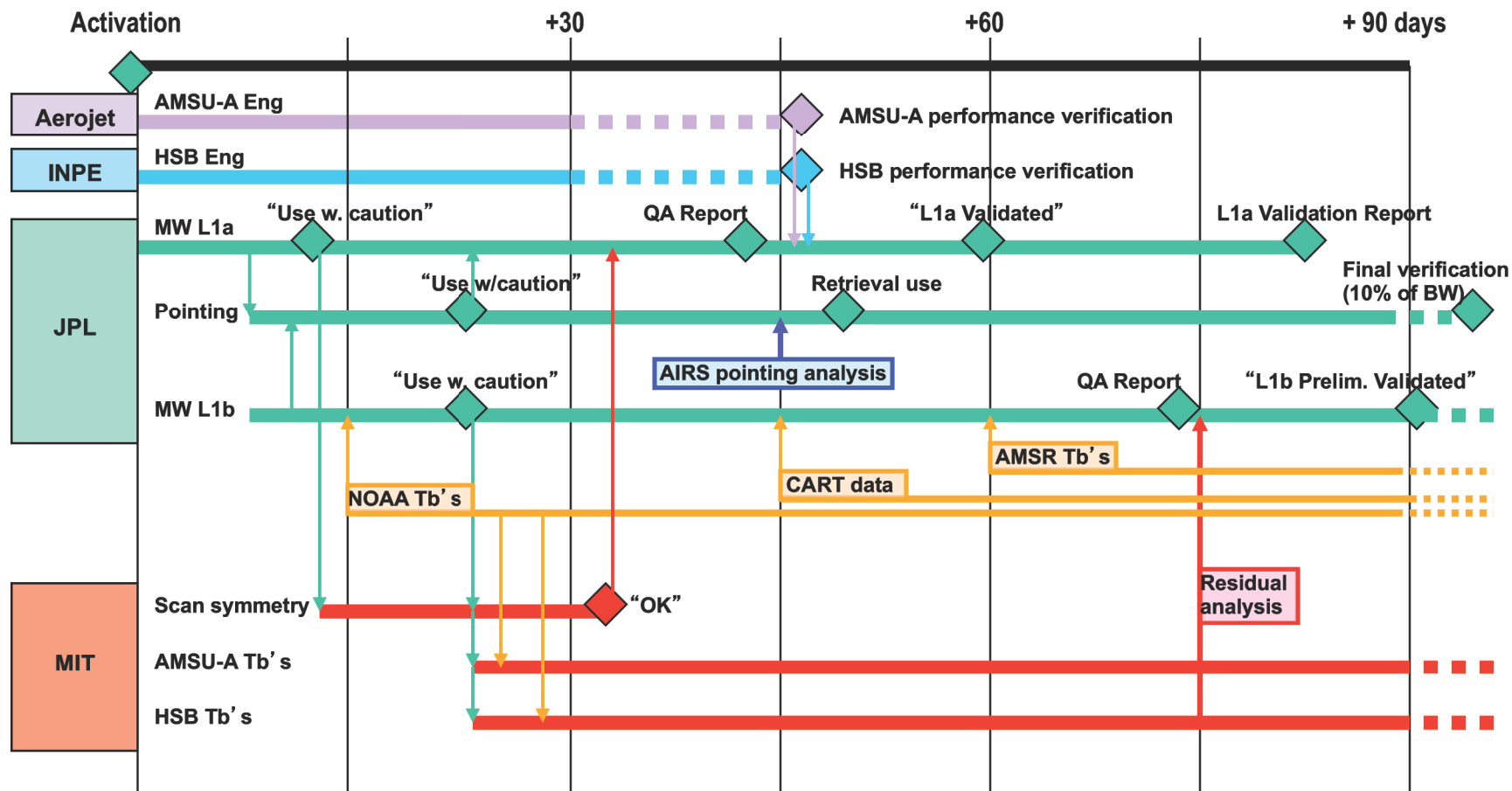
## MICROWAVE INSTRUMENT VALIDATION

# Coastline Analysis

- **Reference maps**
  - HSB: 1-km (30") DEM
  - AMSU-A: 4-km (2' ) DEM
- **Edge detection**
  - Convolution of swath data with 2D edge filter
  - Baseline filter: 3x3 “stochastic gradient” operator
    - *Noise tolerant operator*
- **Comparison**
  - Visually select suitable edge points/features/patterns
  - Determine lat/lon offsets from map; transform to angular offsets
- **Accumulation**
  - Accumulate statistics, indexed by scan position
  - Determine avg., std.dev.
- **Analysis**
  - Determine avg. scan lines: along-track offset & “helix angle”
  - Determine cross-track asymmetry
  - Determine per-scanposition offsets from avg. scan line



# MICROWAVE INSTRUMENT VALIDATION Early Timeline





## Selected ATMS analyses

- **Calibration**
  - Determine orbital variability of calibration parameters
    - $N(\text{cold-cal}), N(\text{warm-cal})$
    - *Cal-coefficients* ( $a_0, a_1, a_2$ ), *gain*
- **Lunar contamination**
  - Identify lunar intrusion into cold-cal FOV
  - Characterize lunar anomaly
  - Evaluate flag
- **Scan bias**
  - Compare with CrIS
    - *Identify equivalent channels (similar weighting functions)*
    - *Track  $\Delta T_b(\text{ATMS-CrIS})$  vs. scan angle*
  - Analyze S/C maneuver data
  - Accumulate statistics for “pure” scenes
- **Pointing**
  - Accumulate  $T_b$  “maps”, compare with true maps
  - Stare mode: coast crossings